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Impact of Wearable Healthcare Devices on Heathcare Outcomes: A Systematic Review

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ABSTRACT
Healthcare delivery in general, chronic illness management, and preventive care are all impacted by the incorporation of wearables into healthcare ecosystems. Providing a thorough understanding of the various facets of wearables' involvement in healthcare is the goal of this review. It examines the many types of wearables, from smartwatches and fitness trackers to specialist medical wearables, explaining their features and possible uses in medical environments. This present study evaluates the scenario in the light of studies conducted in the recent past and present them in the form of a review. The time period of review is 2014 to 2024. most of the studies are related to point in question and provide details about the wearable healthcare devices and their respective outcomes.

Keywords: Wearable healthcare devices, outcomes of wearable devices, medical monitoring, health tracing.

INTRODUCTION

Over the course of its incredible development, wearable technology has evolved from simple devices to essential parts of healthcare plans. Advances in sensor technology, data analytics, and an increasing focus on patient-centered care have all contributed to the incorporation of wearables in the healthcare industry. Beginning as simple fitness trackers, wearable technology has developed into complex gadgets that can track a wide range of health indicators. Innovations in battery life, connectivity, and sensor downsizing have characterized the transition from step counts to full health monitors. Gaining an understanding of this development paves the way for understanding wearables in healthcare today. **Liverani et al (2022)** Wearable technology is being accepted by the healthcare sector as a useful tool for patient health management and monitoring.Wearable technology has emerged as a key source of real-time health data, from consumer-grade gadgets to medical wearables recommended by medical specialists. **Anikwe et al (2022)**

Healthcare delivery in general, chronic illness management, and preventive care are all impacted by the incorporation of wearables into healthcare ecosystems. Providing a thorough understanding of the various facets of wearables' involvement in healthcare is the goal of this review. It examines the many types of wearables, from smartwatches and fitness trackers to specialist medical wearables, explaining their features and possible uses in medical environments. Through an analysis of wearables' range, the paper lays the groundwork for a more sophisticated comprehension of their influence on patient health monitoring. **Krishnamurthi et al (2020)**

This review's main focus is on how important wearables are for tracking and evaluating patients' health. Wearable technology provides a dynamic and real-time approach to patient monitoring, from monitoring vital signs to offering ongoing health insights.

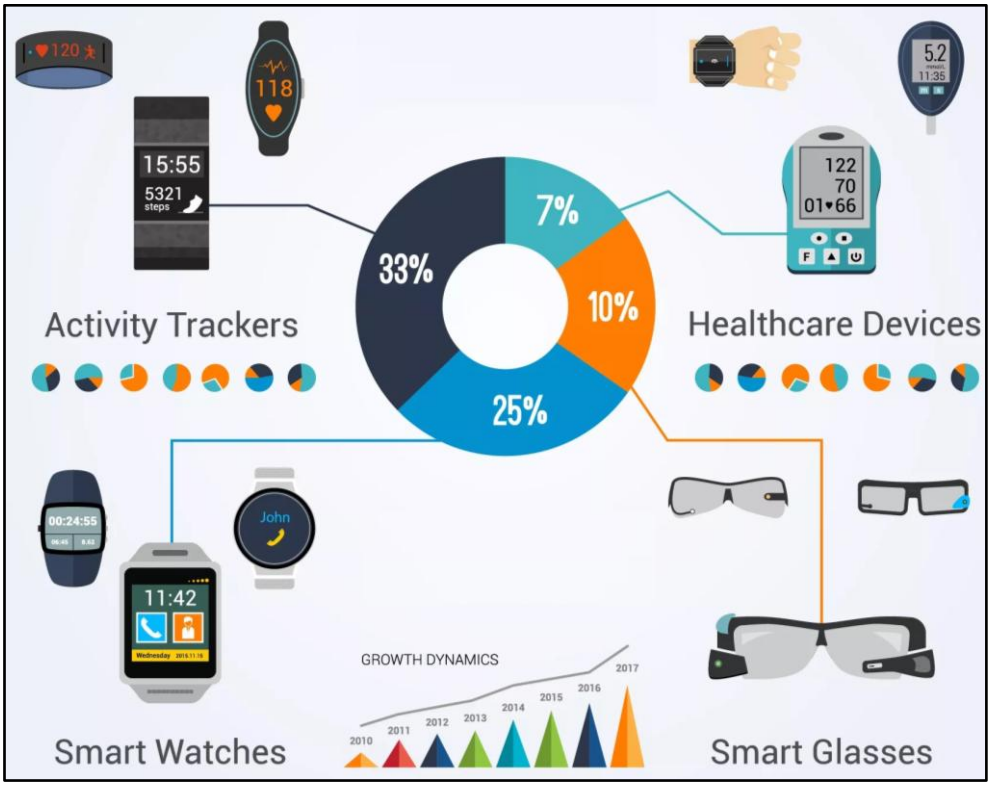
This section emphasizes how important wearable technology is in providing useful data that helps medical practitioners make wise judgments. According to this essay, wearable technology has developed into a vital instrument in healthcare, surpassing its initial status as a consumer device. **Sujith et al (2022)** The thesis claims that patient health monitoring has been transformed by the incorporation of wearables, including smartwatches, fitness trackers, and medical wearables. Wearables leverage technological improvements to provide proactive health management, individualized healthcare, and improved outcomes.

Healthcare wearable technology includes a wide variety of gadgets that are all intended to track and improve different facets of patient health. Fitness trackers serve as wearable technology's first foray into the medical field.

These gadgets use cutting-edge sensors to track a variety of physical activities and workout regimens, going beyond basic step counting. They give customers thorough information about their fitness levels by tracking variables like distance traveled, calories burned, and even certain activity types. Fitness trackers facilitate a comprehensive approach to personal wellbeing by integrating easily with health and wellness apps. These wearables integrate with mobile apps to let users establish exercise objectives, monitor their progress over time, and get tailored advice. **Li et al (2023)**

Users are encouraged to actively participate in their health management through the synergy between fitness trackers and health applications. Smartwatches are now more advanced health monitoring instruments than just timepieces. **Rodrigues et al (2022); Lv et al (2020)**Smartwatches that have sensors like gyroscopes, accelerometers, and heart rate monitors give users access to real-time vital sign data. It is simple for users to monitor their heart rate, identify any anomalies, and learn more about their general cardiovascular health. Smartwatches support medication adherence and general health management in addition to tracking physiological indicators. For water reminders, medication schedules, and other health-related duties, users receive timely messages. By including these capabilities, smartwatches become even more proactive in encouraging healthier living. **Youssef et al (2020)**

One specific category of devices made for ongoing vital sign monitoring is medical wearables. Medical practitioners frequently prescribe these devices, which monitor vital signs like blood pressure, oxygen saturation, and heart rate. The constant flow of real-time data makes it easier to identify abnormalities early and supports prompt medical treatment. Wearable medical technology is essential for improving communication between patients and healthcare professionals. Through integration with medical databases, these wearables guarantee that medical personnel have real-time access to patient data, facilitating tailored healthcare delivery and well-informed decision-making. **Olmedo-Aguirre et al (2022)**



Source:https://www.regulatorymedicaldevice.com/2024/10/miniaturization-wearable-medical-devices-and-innovations.html

Figure 1: Werable Devices and Health Assessment

Benefits of Wearable Technology (Health Monitoring)

Devices that are worn on the body are considered wearable technology. It includes smart watches, smart glasses, and fitness trackers that are used to monitor medical conditions. Blood pressure, heart rate, and other parameters are measured using these devices. Artificial intelligence must be incorporated to guarantee precise diagnoses. In the healthcare industry, wearable technology has grown quickly, enabling constant monitoring from far away. **Bonato et al (2019)** The problems with several health monitoring equipment are covered in this article. Additionally, it outlines upcoming advancements in this area, concentrating on six types of wearable sensor

types. For the purpose of monitoring health, silicon-based pressure sensors have been thoroughly studied. **Catalano et al (2020); Chen et al (2018)**

Because it offers simple answers to fitness and health problems, wearable technology in healthcare has garnered a lot of interest from researchers and businesses. Wearable technology lowers patient discomfort and costs while offering ongoing health monitoring. The need for and interest in health monitoring has increased along with life expectancy. Continuous health parameter sensing and measurement from and around the skin is possible with wearable health monitoring devices. In terms of ongoing personal health monitoring, wearable technology has shown a lot of promise. The primary uses of wearable technology are for recording fitness activities, reducing diagnostic errors, and continuous health monitoring. The study of fitness trackers and smart watches that monitor temperature, steps, heart rate, and pulse has advanced significantly.

Objective of the Study

The objective of the study is to present a detailed review of need, evolution and present state of wearable healthcare devices and impact of the same on respective healthcare outcomes.

RESEARCH METHODOLOGY

Research Design

The researcher has considered exploratory research design in this present study, which is concerned with the process of examining as much secondary data as possible in order to learn about past advancements, the current situation, and potential future directions. The researcher took into account secondary data from earlier research, and the responses to the corresponding questions were determined based on that. Journals of national and international renown were used for the studies. ProQuest Social Science and Humanities, Web of Science, Pub Med, Medline, Scopus, and numerous more relevant sources were among the electronic databases that were accessed.

Time Frame

The study's time scope was from 2014 to 2024 because so many policy decisions were put into effect by many government agencies and allied organizations throughout this time. The other research were not included in the panel because all of the considered studies were presented or published during this time frame.

Selection Criteria

About 75 papers from a variety of sources were gathered by the researcher, and each one had some connection to the research subject. The researcher has determined some of the inclusion and exclusion criteria needed to satisfy the study's goals based on previous research projects carried out in the same field or region. Since English is among the languages best suited for the study's audience, it was determined early on that all studies would be published or presented in this language. On the other side, a few keywords were found, such as "Saudi Arabia," "wearable Technology", "Healthcare", "Outcome" "medical surveillance", "Health monitoring", etc. The studies who do not posses such key words were also excluded. Finally 49 studies were finalized for the present study.

DISCUSSION

1. Patient Monitoring

A dynamic and real-time approach to healthcare is provided by wearable technology, which has completely changed the patient monitoring scene. Vital indicators may be continuously monitored thanks to wearable technology, which provides a steady flow of information on metrics like heart rate, blood pressure, and breathing rate. Early response in the event of abnormalities is made possible by this real-time input, which enables both individuals and medical professionals to quickly identify departures from baseline values. The opportunity for early detection of health issues is presented by wearable monitoring's continuous nature. Vital sign data can be studied over time to find patterns and trends that may indicate minor changes before a medical issue manifests. Timely medical intervention is more likely when this proactive method is used. **Cho et al (2018); Dias, et al (2018)**

Healthcare professionals can receive real-time health data without having to be physically present thanks to wearable technology, which makes remote patient monitoring possible. This capacity is especially helpful for people who need continuous medical care, have chronic illnesses, or are recovering from surgery. Better patient outcomes are a result of remote monitoring's increased accessibility to medical services. **Dolan et al (2018)** Because wearable technology offers a smooth way to monitor patients continuously after they are discharged, it is essential in lowering hospital readmission rates. Wearable technology enables patients to be remotely monitored for complications or indications of decline, allowing for prompt interventions and avoiding needless hospital stays. Chronic diseases including diabetes, high blood pressure, and respiratory disorders can now be effectively managed with wearable technology. **Dorfman et al (2013)**

These gadgets continuously track pertinent health indicators, giving patients and medical professionals useful information for improved illness management and lifestyle changes. Treatment strategies can be more individually tailored thanks to the constant data supplied by wearables. By refining prescription regimens and suggesting lifestyle changes tailored to each patient's needs, healthcare practitioners can customize interventions based on real-time health insights. The effectiveness of managing chronic diseases is improved by this individualized approach. **Dunn (2018)**

Effect on Healthcare Outcomes

Beyond merely gathering data, wearable technology has a significant impact on healthcare outcomes through facilitating tailored healthcare, increasing patient participation, and fostering positive changes in preventive care strategies. **Elsden et al (2020); Gao et al (2019)** People are empowered by wearables because they give them direct access to their health data. Patients may quickly follow progress, keep an eye on their vital signs, and learn more about their health state with the use of mobile applications and user-friendly interfaces. A sense of accountability and ownership for one's health is fostered by this greater transparency. Wearables promote proactive health management by offering actionable insights and real-time notifications. People can actively engage in tracking and enhancing their well-being, set health objectives, and get reminders for taking their medications or exercising. **Hilty et al (2021)**

This change to more active participation is consistent with preventative healthcare practices. Wearable technology continuously gathers personal health data, which helps to provide individualized healthcare. Medical professionals can use this real-time data to customize treatment regimens based on each patient's particular requirements and reactions. Overall patient outcomes are improved and intervention effectiveness is increased with this individualized strategy. Predictive insights into medical issues are made possible by wearables and advanced analytics. To find possible dangers and forecast the chance of a disease developing, machine learning algorithms examine patterns and trends in health data. By facilitating early interventions, this skill shifts the healthcare industry toward a proactive and preventative approach. Wearable technology is essential to encouraging a better way of living. **Inan et al (2017); Kalasin et al (2023)**

Through the tracking of sleep patterns, physical activity, and nutrition, wearable technology gives consumers a thorough understanding of their daily routine. Because of this understanding, people are more likely to adopt better lives and stop chronic diseases from developing or worsening. Wearable technology makes it possible to identify health issues early, which helps with preventive care. Subtle changes that could point to the early stages of a disease can be detected with ongoing monitoring. Early identification can guide timely interventions that can enhance long-term health outcomes and stop the course of illnesses. **Haghi et al (2021)**

2. Related Issues

Although wearable technology has a lot of potential to revolutionize healthcare, a number of issues and concerns need to be resolved to guarantee its broad acceptance and effective incorporation into current healthcare systems. Wearables' ongoing collecting of health data raises questions regarding sensitive data security and privacy. Strong security measures are necessary to prevent unwanted access to the data that wearables broadcast and store. Maintaining the confidentiality of patient data requires the use of secure communication protocols and data encryption. Current data protection laws, such as the Health Insurance Portability and Accountability Act (HIPAA) in the US, must be followed by wearable technology. **Vijayan et al (2021); Ferreira et al (2021)**

By following these guidelines, consumers and healthcare professionals can be sure that the use and storage of health data complies with legal and ethical requirements. One major obstacle still facing wearable technology is its smooth integration with current healthcare systems. When wearables employ various data formats or communication protocols, interoperability problems might occur. To guarantee that wearables can successfully interface with electronic health records (EHRs) and other healthcare systems, standardization initiatives are crucial. Integrating wearable-generated data into workflows presents hurdles for healthcare workers. The smooth incorporation of wearables into clinical procedures may be hampered by time constraints and the requirement for additional training. In order to provide user-friendly interfaces and guarantee that established workflows are not significantly disrupted, technology developers and healthcare providers must work together to address these difficulties.

User involvement is essential to wearable technology's success in the healthcare industry. The requirement for user-friendly designs, effective benefit communication, and resolving comfort and aesthetic concerns are some of the obstacles associated with user adoption. Gamification and tailored feedback are two techniques that can improve user engagement and encourage long-term use. A number of factors, including as comfort, battery life, and device accuracy, can affect wearable use adherence. Continued technological advancements, open communication of device limitations, and user preferences in wearable design are all necessary to overcome these obstacles. Achieving continuous user adherence requires overcoming these obstacles.**Kapoor et al (2020)**

3. Future Prospects

Healthcare wearable technology is set to undergo constant development, with new developments aiming to expand applications, improve capabilities, and completely change the face of proactive and individualized treatment. More sophisticated biosensors that can record a wider range of health data will be incorporated into wearables in the future. Wearables will be able to assess biomarkers more precisely thanks to advancements in sensor technology and miniaturization, increasing their use in illness monitoring, diagnosis, and therapy optimization. Future wearables are probably going to use multimodal sensors, incorporating features like ambient sensors, photoplethysmography (PPG), and electrocardiography (ECG). A more thorough and contextualized picture of a person's health will be made possible by the convergence of sensor modalities, allowing for more precise and comprehensive health evaluations.

When artificial intelligence (AI) algorithms and powerful data analytics are combined, wearables will become predictive tools. In order to find patterns, forecast health trends, and offer tailored advice for managing and preventing disease, these algorithms can examine enormous datasets. An approach to healthcare that is proactive and predictive will be fueled by the convergence of wearables and AI. Real-time analytics will be made possible by edge computing, which processes data closer to the point of origin (the worn electronics). This lowers data transfer latency, enabling wearables to deliver insights instantly. Wearables are better able to provide quick decision assistance and continuous monitoring when edge computing is integrated into them. Wearables will be used for therapeutic purposes in addition to monitoring in the future. **Tariq et al (2024)**

Wearable technology with capabilities like drug delivery systems or transcutaneous electrical nerve stimulation (TENS) may provide individualized and non-invasive therapeutic treatments. With this increase in capabilities, wearables become proactive tools for treating a range of medical disorders. Wearable technology will be essential to the integration of telemedicine systems. Wearable technology will act as a link between patients and medical personnel as remote healthcare delivery grows in popularity. The scope of virtual consultations, diagnostics, and continuous monitoring will be expanded by this integration, promoting a patient-centered and more accessible healthcare paradigm. Wearables of the future will put an emphasis on user-centric design to improve overall user experience, comfort, and aesthetics.

Wearable technology that blends in with people's lifestyles thanks to advancements in materials, form factors, and customisation possibilities will encourage consistent use and adherence. Wearables that combine fashion design and technology development will be both fashionable and useful. The combination of fashion and technology will help wearables become commonplace accessories, which will lessen stigma and increase public acceptance of ongoing health monitoring. **Adeghe et al (2024)**

CONCLUSION

A new era in healthcare has been brought about by the incorporation of wearable technology, which presents previously unheard-of chances to improve patient outcomes and customize care. This study examined the many facets of wearable technology's function in healthcare, with particular attention to how it affects patient monitoring, healthcare outcomes, obstacles, opportunities, and ethical issues. We investigated how wearables support remote patient monitoring, ongoing health tracking, and the treatment of chronic illnesses as part of our investigation into patient monitoring. The promise for wearables to transform patient care is demonstrated by their capacity to monitor vital signs in real-time, diagnose health issues early, and lower hospital readmission rates.The conversation on healthcare outcomes focused on the ways that wearables support better patient participation, individualized treatment, and constructive changes in preventive care strategies. The user-centric and outcome-driven character of wearable technology is highlighted by its ability to empower patients with access to health data, support proactive health management, and customize treatment programs based on personal health data. Wearable technology adoption in the healthcare industry is not without its difficulties, though. To achieve responsible and equitable implementation, careful attention must be paid to privacy concerns, user uptake, interaction with current healthcare systems, and ethical considerations. To establish consumer trust and promote a sustainable healthcare ecosystem, it is critical to strike a balance between the advantages of wearable technology and ethical issues.

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